Thrust Stand Performance Measurements of an Ablative Gallium Electromagnetic Thruster

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The gallium electromagnetic (GEM) thruster a multi-MW-level ablative accelerator designed to mitigate the life-limiting cathode erosion inherent in magnetoplasmadynamic (MPD) thrusters. The benefits of using gallium as a propellant include its low toxicity and a low first ionization potential (6 eV). Gallium can easily be stored as a condensable propellant, and due to its conductive nature and 30°C melting point, can be fed to the thruster using a robust electromagnetic pump possessing no moving parts. This presentation details the performance measurements made on a laboratory scale thruster. The geometry of the thruster is being optimized to obtain a thruster efficiency exceeding 50% at a specific impulse of 3000 seconds.

Measurements obtained during testing include the discharge current, arc voltage, mass bit, and impulse bit. Tests are conducted in Vacuum Facility 3 (VF-3) at NASA Glenn Research Center, a chamber 1.5 m in diameter and 4.5 m long. The facility is evacuated with four oil diffusion pumps with a typical background pressure of 2 μtorr prior to each shot. A semiconductor-type aircraft turbine combustor spark igniter is mounted 5 cm from the face of the thruster and pulsed to initiate the discharge. The thruster is driven by a pulse forming network (PFN) with a peak discharge current of 20 kA. The thruster is tested with electrode radius ratios ranging from 3-8. A torsional-type thrust stand is used to measure the impulse bit of the coaxial thruster. The momentum per pulse is determined as a function of the thrust stand deflection, spring stiffness, and natural frequency. The arc impedance, which can be correlated to the electromagnetic acceleration mechanism, is measured as a function of the discharge current. A solid gallium cathode is used in the present work to obtain accurate measurements of the mass ablated per pulse. The mass bit is measured by weighing the electrodes before and after test firings using a mass balance with a resolution of 10 μg. The impulse bit, mass bit, and arc impedance are used to calculate the thruster efficiency and specific impulse as the geometry of the thruster is varied.